

Recovery of Fruit Essences in Preserve Manufacture

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This paper presents a method for recovering, in essence form, the fruit aromas normally lost in the conventional vacuum-pan processes of making jams and preserves. A surface condenser is used instead of the usual water-jet or barometric condenser, and its condensate is processed to form a strong essence. The essences thus obtained from strawberry, cherry, peach, and blackberry have the characteristic odor of the cooking fruit. They can be put back into the preserve to enhance its flavor, or used as flavoring materials for other fruit products.

In the usual procedures for making fruit jams and preserves, which involve boiling off 10 to 30% of the water contained in the fruit, most of the substances which give fragrance to the fruit are driven off with the steam. Our grandmothers' kitchens bore odorous testimony to the loss incurred when the fruit was boiled in open kettles, and in vacuum pans the only difference is that the fragrant substances are lost in the condenser water instead of to the atmosphere. The substitution of a surface condenser for the more usual water-jet or barometric type, and the use of low-temperature water for the condenser or for an after-cooler, constitute the first step in recovering this loss. The next step is concentrating the collected condensate in an essence-recovery apparatus based on the principles developed at the Eastern Regional Research Laboratory for recovering and concentrating essence from fruit juices. By this procedure nearly all the aroma otherwise lost from each hundred pounds of preserves can be concentrated into less than a pint of essence. It is to be noted that the manufacture and use of such essences ("volatile flavor concentrates") are subject to regulations of the Bureau of Internal Revenue (1).

Reincorporation of essence into preserves^b improves their flavor and aroma, giving the preserves a stronger and more fruity character. Tests now under way on storage of these preserves at room temperature indicate that, at least with certain fruits, the improved flavor does not last many months. A manufacturer whose normal processing gives products of adequate quality for his market might profitably sell the essences as by-products. There is now a market for volatile fruit concentrates for contributing true fruit flavor in the manufacture of beverages, fountain sirups, ice creams, and confectionery.

In pilot-plant work at the Eastern Regional Research Laboratory, application of this process to cherry, strawberry, peach, and blackberry preserves has been investi-

gated. In each case, an essence of good aroma was obtained. Strawberry, blackberry, and cherry were strong and excellent. The peach preserve was made, as usual, from canned peaches; hence the essence had that characteristic odor and was not very strong.

EXPERIMENTAL

Condensing the vapors. In making a typical 2000-pound batch of preserves, the water evaporated may be about 380 pounds. For instance, the manufacturer may mix in an open steam-jacketed kettle 1240 pounds of frozen sugared cherries previously thawed (containing 1 pound of sugar per 4 pounds of fresh cherries), add 932 pounds of sugar, 12 pounds of dry pectin dissolved in 181 pounds of water, and 15 pounds of 50% citric acid solution, heat the mixture to 150° F. (65.5° C.) and stir for 5 minutes. The hot mixture is drawn into a vacuum pan, and the vacuum is raised to 25-28 inches; some evaporation thus occurs spontaneously. Steam is then turned into the jacket, and evaporation is continued until the density of the sirup reaches about 63° Brix. The vacuum is then broken by letting air into the pan; this is to force the sirup into the interior of the individual cherries. Next the vacuum is restored, and evaporation continued to about 67° Brix. Once more the vacuum is broken and restored, and when the density reaches 68° Brix the batch is discharged to an open kettle, where it is heated to 180° F. (82° C.) for packaging. Steam is kept in the jacket during this entire period of cooking in the vacuum pan, which usually takes 45 minutes. Carry-over or entrainment of liquid with the vapors should, of course, be avoided as far as possible, for this might cause fermentation of the condensed vapors unless they are processed the same day.

The water vapor evolved from the batch (in the quoted example amounting to 380 pounds) carries away with it most of the odorous substances originally present in the fresh fruit or developed during the cooking. To recover these substances, the present process uses a tubular surface condenser to condense the vapor, instead of the customary type of condenser in which the vapors are directly mixed with water and thus discarded. Since many of the odorous substances have low boiling points, the condenser must be so designed as to cool the condensed vapor as low as feasible and thus minimize the loss of these volatile substances. The frequent breaking of vacuum introduces a considerable quantity of air into the vapor going to the condenser, and of course this air as it leaves the condenser carries some volatiles away with it. Since the air leaves saturated with respect to the liquid components of the condensate, it must be cooled in order to reduce the loss of volatiles to a small amount. This also calls for consideration in designing or choosing the condenser. It should be of the type in which the vapor is inside vertical tubes, and the shell should be well baffled so as to give the cooling water a definite path countercurrent to the flow of the vapor. Thus both the condensate and the air in the latter part of their travel can be well cooled by the incoming water. The vertical type gives the best cooling of the condensate, since it flows down over the entire surface of the tubes instead of along the bottom as in horizontal or inclined tubes. The type of condenser having the vapor outside the tubes is undesirable because of the impossibility of properly cleaning the vapor and condensate spaces. As discussed later, the degree of cooling necessary for satisfactorily complete recovery is different with different fruits; it is in the range of 60-80° F. (15.5-26.5° C.). The degree desirable in any particular installation is an economic question, varying with the availability and cost of low-temperature water.

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^b The restoration of aroma to preserves by the reincorporation of essence should be cleared with the Food and Drug Administration for compliance with the standards of identity for these products.

If a manufacturer happens to have a small supply of very cold water in addition to a large supply of somewhat warmer water, an attractive arrangement is the use of a separate after-cooler, through which condensate and air pass on leaving the main condenser, the after-cooler being supplied with the coldest water and the water leaving it being added to the supply of water for the main condenser. The after-cooler should have vapor passages of liberal cross-sectional area to avoid high frictional resistance when the vacuum is being raised. If multi-tubular, it should be arranged so that the incoming condensate is well distributed among the various tubes.

The apparatus used in our experimental work (Figure 1) included more items of equipment than would be used in a com-

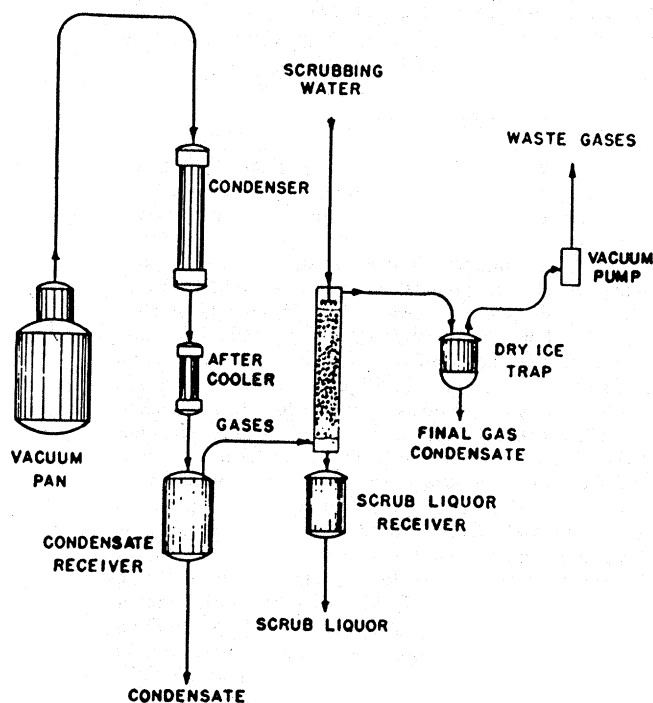


Figure 1. Apparatus for investigating recovery of aroma lost in the manufacture of preserves.

mercial plant. To determine how much cooling of the condensate would be economically desirable, we used an after-cooler. Further, to determine the amount of aroma escaping from the after-cooler in the vent gases, we passed them up through a scrubbing tower. Cold water flowing down through this tower absorbed the residual aromatic constituents for later evaluation. In making blackberry preserve, cooling the condensate only to 82° F. (28° C.) was adequate to reduce to a commercially negligible amount the loss of volatiles in vent gas from the after-cooler and obtain an essence of good character. With strawberries, however, it was necessary to cool the condensate to about 62° F. (16.5° C.) to achieve this result. With peaches (canned as is customary for preserve manufacture) and with cherries, cooling to 62° F. was satisfactory, but the necessity of cooling this low was not established. These temperature limits were arrived at by odor and taste tests, made by a trained panel in a manner similar to the tests for vaporization described later.

To achieve cooling to 62° F. requires water at 50-55° F. (10-13° C.) in sufficient quantity to operate at least an after-cooler. Many manufacturers may have such a supply in winter, and hence could obtain a high yield of satisfactory essence from the four kinds of fruits we have tested, and probably from other fruits not yet investigated, without resort to the other devices described below. If such cold water is not available in summer, as from deep wells or by refrigeration, high essence recovery from some fruits, such as strawberries, could not be obtained by this method, but could be had by vent gas scrubbing, as explained later. Refrigeration of the small quantity of water needed for an after-cooler is not impracticable. For instance, if

the temperature of the main water supply is 75° F. (24° C.), each ton of preserves would require only about 60 gallons of water at 50° F. (10° C.) and production of 1 ton per 45 minutes would require a 2-ton refrigerating plant, with a 2-horsepower motor.

An alternative scheme for operating without low-temperature water is the use of a scrubbing tower for the air and gases vented from the condenser; in this case no after-cooler is needed. The vent gases, carrying, of course, a certain amount of vapors, pass up through the tower while fresh water at normal temperature flows down. The water leaving the bottom of the tower is collected and added to the condensate for processing into essence. If all the air exhausted from the vacuum pan during the raising of vacuum were passed through the scrubbing tower, a tower of an unnecessarily large diameter would be needed, which would require an excessive amount of water. Therefore, since this air contains very little aroma (because the contents of the pan are not boiling) the tower can be bypassed and the air sent directly from the condenser to the vacuum pump during these periods.

Making the essence. In order that the aroma have commercial utility as a source of flavor, it must be concentrated to essence. This can be accomplished by processing the condensate, or condensate plus scrub liquor, by the method developed at this Laboratory for recovery of essence from fruit juice.

Apparatus to produce essence directly from fruit juices has been described in previous publications of the Eastern Regional Research Laboratory (6, 2, 3, 4, 7^a). For recovering essence from condensate, the process will be somewhat simpler. Since the condensates are not as sensitive to heat-damage as are fruit juices, the preheater and vaporizer need not be designed for such high velocities as fruit juices require. The stripped condensate from the separator can be discarded and therefore need not be cooled. The vent gas need not be scrubbed with water (obtained from the bottom of the fractionating column). It is sufficient to chill thoroughly the vent gas, primarily to assure condensation of its accompanying volatiles. The chilling can be accomplished most simply by passing the gas up through a small packed tube down which flows chilled essence. This tube and a small precooler for the essence are immersed in an ice bath. This simplified essence recovery system is shown in Figure 2. The essence apparatus works continuously, not batchwise. The general principle is as follows: the feed liquid (condensate containing the aroma) is pumped at a constant rate through a preheater, which heats it to its boiling point, and through a vaporizer in which a chosen percentage of it is vaporized, each controlled by adjusting its steam supply. The mixture of vapor and residual liquid is sent to a separator, from which the liquid is discarded by means of a tight-closing steam-trap and the vapor sent to a fractionating column. By means of the column with its condenser and reflux splitter, most of the water is discarded as column bottoms, and a concentrated essence is produced. The air that enters with the feed liquid is vented from the reflux splitter and chilled before being discarded to the atmosphere.

Determination of the proper percentages to vaporize out of the various condensates was made by odor tests of the essences and the liquids from which they were stripped. The percentage chosen did not necessarily represent complete recovery of all volatile constituents in the distillate, for complete recovery would be uneconomical in commercial practice. Recovery was judged adequate when the essence had the character of the fruit from which it was derived and an essence made from a second stripping of the stripped condensate was of only very low potency. For cherries and peaches, the vaporization thus arrived at was 20%, for blackberries, 30%, and for strawberries, 40%. For any one fruit, these figures may conceivably vary according to the variety of the fruit; the varieties we used are discussed later.

^a In the article cited under 7 there is an important error. On page 2, column 2, line 12, it should read "0.104-inch" and not "0.014-inch."

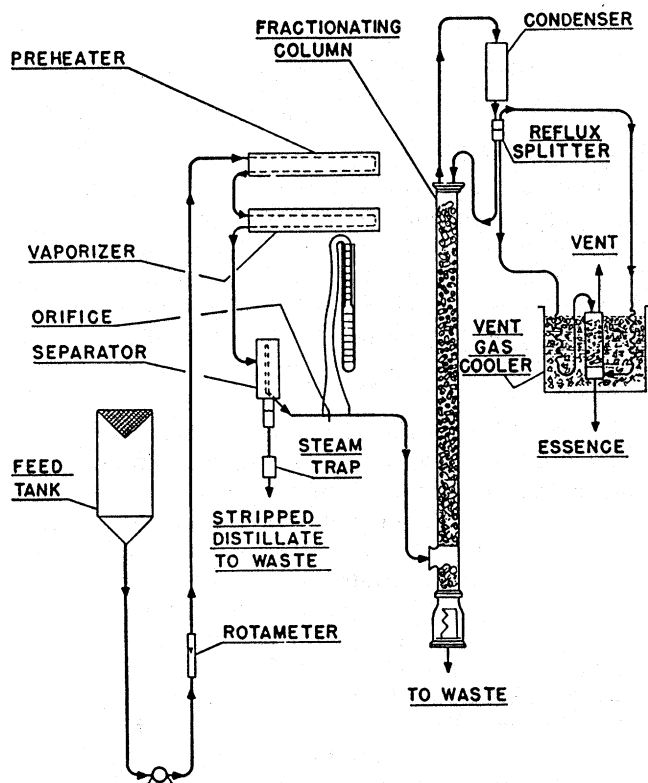


Figure 2. Apparatus for producing essence from distillates.

The strength of the essence produced can be adjusted by merely changing the volumetric rate at which it is drawn off from the reflux splitter; doubling this rate will produce twice as much essence, but of only half the strength. For instance, in the example given, the 380 pounds of condensate can be made to yield 9.5 pounds of essence, which will therefore be 40 times as strong in aroma as the condensate, or nearly so. If the drawoff be adjusted to produce 19 pounds of essence from 380 pounds of condensate, the essence will be only 20 times as strong as the condensate. A convenient commercial figure for expressing the strength of the essence is the number of pounds of preserve from which 1 fluid ounce of essence is made. This figure can be called "potency"; in the example given, recovering 9.5 pounds of essence (that is, 146 fluid ounces) from 2000 pounds of preserve, the potency of the essence would be $2000/146$, or 13.7. In previous publications dealing with the production of essence from fruit juices, the term "fold" has been used to designate the strength of the essence. For instance, "150-fold essence" means that 1 gallon of essence contains all, or nearly all, the aroma from 150 gallons of juice. This concept cannot be applied to essences derived from preserves, as it implies substantially complete recovery of aroma from the juice or fruit. Obviously, some aroma remains in the preserve. This work is directed only to recovering that which is normally lost.

Storage and utilization of the essence. If the essence is to be reincorporated into the preserve, it is of course not essential to good flavor that each lot of essence be used with the kettle-batch of preserve from which it was obtained. Since the essence-making apparatus is inherently continuous-acting, and takes 15 to 30 minutes

to come to equilibrium, the best scheduling is to run it a whole day on condensate from one fruit rather than to switch frequently from one fruit to another. If it becomes necessary to hold condensate overnight it should be kept under refrigeration to prevent the possibility of fermentation. The essences will normally be free from sugar. Nevertheless it is recommended that essences be kept in cold storage, in well-filled and tightly stoppered containers, to minimize the possibility of deterioration.

RESULTS OBTAINED ON VARIOUS FRUITS

Cherries. Montmorency cherries, packed frozen with 1 pound of sugar per 5 pounds of cherries, were used. The batch was concentrated at 25 inches of vacuum from 61° Brix to 71° Brix, the vacuum being broken and restored twice during the concentrating. The batch was then heated to 180° F. (82° C.) and drawn off into glass jars. The condensate was cooled to 64° F. (18° C.) by the condenser, hence no separate after-cooler was used. The condensate, which amounted to about 18 pounds, had a good strong odor typical of cherry preserve. The vent gas from the condenser was scrubbed with chilled water totaling 11 pounds; the resulting scrub liquid had so little odor that even a 25-fold essence made from it had a negligible amount of aroma. Hence the conclusion was drawn that if the condensate is cooled to 62° F. scrubbing of the vent gas is unnecessary. For experimental confirmation, the vent gas was sent from the scrubbing tower to a dry-ice trap; the liquid collected here was odorless and a chemical test (titration with alkaline permanganate solution) showed absence of organic substances, proving the adequacy of the scrubber as an indicator of loss, if any, from the condenser.

The condensate was processed in the essence-recovery apparatus, vaporizing 20% and making an essence of 25-fold with respect to the condensate. This was found to have in a very strong degree the odor characteristic of cherry preserves.

The stripped condensate, that is, the 80% remaining after passing through the vaporizer of the essence unit, had a definite cherry aroma. It was, therefore, processed to make a 25-fold essence, but the essence produced had so little aroma as to be considered not worth the expense of recovering it in commercial practice. In spite of its little odor, however, analysis by alkaline permanganate titration showed that it contained 23% of the total organic material originally present in the condensate. This illustrates the fact that chemical determination of total organic substances, as for instance by permanganate titration, although useful for certain experimental purposes, does not give a true indication of the relative value of the actual aroma of different products. For instance, ethyl alcohol, a preponderant component of most essences, responds to the permanganate test but actually contributes little or nothing to the aroma.

Addition of the essence from the condensate to the preserve made in the vacuum pan produced marked improvement in both aroma and taste. The flavor was more fruity, having more of the character of the fresh cherry. The essence itself had a fine cherry odor. It

should prove a valuable and salable byproduct for a preserve manufacturer whose market does not demand, nor pay for, an improvement in quality over his standard preserve.

Peaches. For starting material, canned peaches were used, in accordance with customary practice, to avoid the darkening that fresh peaches would undergo in preserve manufacture. Using a mixture of 25% Elberta and 75% Clingstone peaches, we made a preserve and collected the distillate at 62° F. (16.5° C.). It had a good odor of canned peaches. The intensity of the odor was of course much less than that of cherry essence, since canned peaches themselves have little odor. An essence made from the effluent liquid from the vent gas scrubber contained little aroma; therefore, it was not considered commercially worth while to scrub this gas. Vaporizations of 20, 25, and 30% were given to the distillate in the essence apparatus. The stripped distillates were all very weak in odor and practically indistinguishable from each other, showing that no increase in recovery of aroma would be obtained by vaporizing more than 20%. A batch of essence made from the distillate at 20% vaporization was returned to the preserve from which it had been obtained. This gave a definite improvement in both aroma and flavor.

Strawberries. With strawberry preserve, trials were made to determine whether distillate temperature as high as 76° F. (24.5° C.) would give adequate recovery without scrubbing. A frozen sugared-pack of Marshall berries was used (3 parts of berries to 1 of sugar). When cooling the distillate only to 76° F., the liquid from the vent gas scrubber had a fairly strong odor. An essence made from this scrub liquid (using 20% vaporization) had a strong odor of strawberry jam. Therefore, if the distillate is collected at as high a temperature as 76° F., scrubbing the vent gas is necessary for good recovery of aroma. A vaporization of 40% in the essence apparatus is adequate to recover substantially all the aroma present in the combined distillate and scrub liquor.

Cooling the distillate and vent gas to 62° F. (16.5° C.) gave satisfactory recovery of aroma without scrubbing the vent gas. Also 40% vaporization was necessary in stripping the distillate in the essence apparatus; the gain by using 50% was insignificant. An essence so made, when returned to the preserve from which it had been obtained, enhanced the flavor and aroma to a marked degree; the resulting full-flavor preserve had an aroma and flavor stronger and more characteristic of fresh strawberries.

Blackberries. Low cooling of the distillate and vent gas was not necessary with blackberries; a temperature of 82° F. (28° C.) was adequate to reduce vent gas loss to a very small amount. The distillate had a fine strong odor similar to that of the preserve. A vaporization of 30% in the essence unit was required, and a 25-fold essence thus made appreciably improved the preserve in aroma and flavor. An interesting point here was that the full-strength essence had an odor somewhat different from that of the preserve, but when diluted with water it regained the true odor of preserve. It is not always possible to judge the value of an essence by smelling it

at full strength. Blackberry essence recovered as described above can be a potent source of blackberry flavor.

CONCLUSION

By the methods and essence-recovery apparatus presented in this paper, a manufacturer of fruit preserves and jams can recover, in the form of concentrated essence, fruit aromas which are lost in the conventional method of manufacture. The essences could be sold to manufacturers of flavoring materials or other fruit products, or can be put back into the preserves to enhance their flavor.

In winter, when at least a part of the water supply is at 50-55° F. (10-13° C.), excellent recovery of aroma from the vapors can be obtained without refrigeration or scrubbing, hence with the minimum investment for equipment. In summer, with water temperatures of 65-75° F. (18.5-24° C.) some fruits (blackberries) will give excellent recoveries. With other fruits (strawberries), the recovery of aroma is less complete unless the condensed vapors are cooled to 60-65° F. (15.5-18.5° C.) or the vent gases from the condenser are scrubbed. The cooling will need a small supply of water at 50-55° F.; scrubbing will require the installation of a small packed tower and a supply of odorless water at normal temperature.

The experimental work thus far done on 4 fruits (strawberries, cherries, peaches and blackberries) has indicated the desirability of further trials on a larger scale, especially with additional fruits. Such trials, utilizing vapors evolved from vacuum pans in an actual preserve manufacturing plant, are planned as part of the continuing research program of the Eastern Regional Research Laboratory. They are expected also to provide a sufficient quantity of essences for commercial evaluation in food products other than preserves.

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